Remarks

Reconsideration of the application is requested.

Claims 1-35 remain in the application. Claims 1-3, 5, 7, 11-13,, 15, 17, and 19-23 are subject to examination and claims 8-10, 14, 16, 18, and 25-35 have been withdrawn from examination. Claims 12, 17, 20, and 22 have been amended.

In the items under "Claim Objections" on page 2 of the above-identified Office Action, the Examiner objected to claims 12, 17, 20, and 22 because of certain specified informalities. The Examiner's suggested corrections have been made in the claims.

In the second paragraph under "Claim Rejections - 35 USC § 102" on page 3 of the above-identified Office Action, claims 1-3, 7, 11-13, and 15 have been rejected as being anticipated by Miyata et al. (U.S. 5,500,559) (hereinafter "Miyata") under 35 U.S.C. § 102(b).

As will be explained below, it is believed that the claims were patentable over the cited art in their original form and, therefore, the claims have not been amended to overcome the references.

Before discussing the prior art in detail, it is believed that a brief review of the invention as claimed, would be helpful. Claim 1 calls for, *inter alia*, a method of producing a structured layer, which comprises the following steps:

providing a prestructured substrate;

applying to the prestructured substrate a precious metal and a **donor material containing an additive which is not a precious metal** in two or more layers;

subjecting the layers to **heat treatment** at a temperature of between approximately 400°C and approximately 800°C, **such that the additive diffuses into the precious metal** and an alloy layer is produced; and

polishing the alloy layer by chemical and mechanical means.

Thus, there is provided according to the present invention a method for structuring even precious metal electrodes by conventional CMP steps, in particular with the aid of conventional slurries, such as are already used for structuring non-precious metals. It is believed this is obtained by the fact that the chemically active components of the slurry attack the additive to the precious metal in the alloy, as a result of which the surface of the alloy layer is

roughened and the chemical mechanical removal of the precious metal is thereby increased. However, the good electric conductivity and the inertness, in particular with regard to gas phase CVD processes with subsequent heat treatments, of the original precious metal layer are substantially maintained in the case of the alloy layer that is formed. Thus, the method of the present invention results in an electrode which has a very good electrical conductivity. Moreover, in the case of gas phase CVD depositions and subsequent heat treatments (annealing processes), the electrode is inert to the greatest possible extent. The behavior of the electrodes in the case of wet-chemical polishing and structuring operations is, however, changed by the modification according to the present invention in such a way that the electrodes can be treated with conventional slurries.

The donor material can preferably be substantially only the additive. Thus, for example, it is possible to produce a pure titanium layer on a platinum layer. The subsequent heat treatment diffuses titanium into the platinum, thus producing a platinum/titanium alloy. However, it is also possible to use a titanium oxide layer (TiO_x) as donor material. The subsequent heat treatment diffuses only the titanium into the platinum, such that, on the one hand, a platinum/titanium alloy is produced, while on the other hand a titanium oxide layer with a different stoichiometric composition is left

behind on the alloy layer. This titanium oxide layer is removed from the alloy layer by an additional etching step, for example with HF or HCL.

Preferred precious metals which may be used in conjunction with the present invention are the precious metals from the transition Group 8b of the Periodic Table of the Elements, and gold (Au). Osmium (Os), iridium (Ir) and platinum (Pt) belong to Group 8b, Ir and Pt being particularly preferred.

The additive, which is not a precious metal, can preferably be selected from Ti, Ta, W, Bi, Ru and/or Pd and oxides thereof.

The donor material, which contains the additive, can preferably be selected from Ti, TiN, Ta, TaN, W, WN, Bi, BiO_x, IrO_x, $IrHfO_x$, RuO_x and/or PdO_x.

Miyata discloses a method for manufacturing a semiconductor device with a highly reliable wiring structure. See Figs. 2A to 2D. As a first step, as shown in Fig. 2A, an insulating film (SiO_2) 12 deposited on a silicon (Si) substrate 11 with grooves 13 is formed in the insulating film 12. Then, titanium and palladium are deposited in sequence on the insulating film 12 by sputtering or CVD to form a titanium film 14 of the first metal layer and a palladium film 15 of the second metal layer (Fig. 2B). Thereafter, the palladium

film 15 serves as a cathode and is electroplated to form a silver film 16 of the third metal layer thereon (Fig. 2C). Then, the silver film 16 outside the grooves 13 is removed by polishing to form groove-shaped wiring layers 17. After that, the resultant structure is annealed at a temperature of about 700°C, and the titanium film 14 and the palladium film 15 are alloyed with each other, thus forming intermetallic compounds 18 (Fig. 2D). Consequently, the wiring layers 19 each having the alloys of titanium and palladium and the groove shaped wiring layers 17 of silver whose resistivity is lower than that of aluminum, are obtained (see column 3, lines 7-37).

However, if the palladium film 15 is considered the "precious metal" layer of claim 1 and the titanium film 14 is considered the "donor material" layer of claim 1, then Miyata does not disclose an "additive" recited in claim 1. Further, the claimed limitation of "polishing the alloy layer" means that the "polishing" step is carried out after the "heat treatment" step, while in Miyata, the polishing is carried out <u>before</u> the heat treatment. Also, because polishing is carried out <u>before</u> the heat treatment in Miyata, it is not an "alloy layer" of titanium and palladium which is polished but two separate layers, one of palladium and the other of titanium. Further, Miyata does not disclose that the polishing is carried out by "chemical and mechanical means" as recited in claim 1.

Therefore, it is apparent that Miyata does not disclose the aforementioned features of claim 1.

Moreover, Miyata is directed towards providing a method for manufacturing a highly integrated wiring structure on a semiconductor device which is highly reliable, provides a low resistance and minimizes electromigration. The problem is solved by using silver as a low resistance material and by applying an anneal to provide a solid solution between the silver layer and the palladium layer. A lowering of the resistivity is also achieved by the anneal, which produces an intermetallic compound 18 formed by the titanium film 14 and palladium film 15 (see column 3, lines 42-47).

The problem solved by the present invention, in contrast to Miyata, is to provide a method to structure precious metal layers that absent such a method "can be etched chemically only with difficulty, or even not at all" with the consequence that "these materials prove to be extremely resistant even in the case of the use of so-called CMP (chemical mechanical polishing)" (see page 4, lines 4-11 of the instant specification). According to the present invention, the problem is solved by applying a "donor material containing an additive which is not a precious metal" (see claim 1) to roughen the surface of the alloy layer with the consequence

that "the chemical mechanical removal of the precious metal is thereby increased" (see page 7, lines 15-19 of the instant specification).

Therefore, it is apparent that the disclosure of Miyata is distinctly and significantly different than that of the present invention. While Miyata is trying to provide an intermetallic compound 18 having a low resistance and a solid solution between silver and palladium, the present invention is directed toward making a precious metal layer weak for removal by chemical mechanical polishing.

Further, as explained above, Miyata does not disclose "a donor material containing an additive" as claimed. The use of the additive, however, is an important aspect of the present invention, since it roughens the surface of the alloy to permit a chemical mechanical removal (see page 7, lines 14-23 of the instant specification). Miyata does not disclose an "additive" and does not disclose the use of an additive for permitting removal of a precious metal layer.

Further, as explained above, Miyata does not disclose that an alloy layer is polished. "Polishing the alloy layer" as recited in claim, however, is an important feature of the present invention since it is only the alloy which can be removed by a chemical (and mechanical) polishing.

In Miyata, in contrast, the silver layer, the palladium layer and the titanium layer, rather than the alloy, are polished.

Miyata does not show "...a **donor material containing an additive which is not a precious metal** in two or more layers; subjecting the layers to **heat treatment** at a temperature of between approximately 400°C and approximately 800°C, **such that the additive diffuses into the precious metal** and an alloy layer is produced; and **polishing the alloy layer by chemical and mechanical means"**, as recited in claim 1 of the instant application. (emphasis added)

In the third paragraph under "Claim Rejections - 35 USC § 102" on page 4 of the above-identified Office Action, claims 1, 5, 13, and 17 have been rejected as being anticipated by Nogami et al. (U.S. 6,022,088) (hereinafter "Nogami") under 35 U.S.C. § 102(e).

Nogami discloses (in Figs. 1 to 3) a method for manufacturing high conductivity copper interconnects for high speed integrated circuits. Referring to Fig. 1, a barrier layer 11 is sputter deposited to line via hole 12 in dielectric interlayer 10. Undoped Cu layer 13 is then sputter-deposited to fill via hole 12 and form a layer on the upper surface of dielectric layer 10 with the barrier metal layer 11

therebetween. A layer of doped Cu 14 is then sputter-deposited on the undoped Cu layer 13 (see column 5, lines 56-65). The dopant is to improve the electromigration resistance of the copper filled opening and may include Pd, Zr, Sn, Mg, Cr and Ta (see column 5, lines 23-37). Annealing is then conducted to diffuse dopant element atoms from doped Cu layer 14 into undoped Cu layer 13 forming Cu layer 20 filling via hole 12 and on barrier layer 11, as shown in Fig. 2. By annealing to diffuse dopant element atoms from doped Cu layer 14 into undoped Cu layer 13, the electromigration resistance of Cu layer 20 filling the hole is significantly improved. CMP is then performed so that the surface of the electromigration resistant Cu via 20 is substantially coplanar with the upper surface of the dielectric interlayer 10 (see column 5, line 57 to column 6, line 8). The annealing is carried out at a temperature of about 350°C to about 450°C (see column 5, lines 38-41).

However, copper, according to the International Union of Pure and Applied Chemistry (IUPAC) rules, is not one of the metals known as a precious metal. According to the IUPAC rules, precious metals are only Au, Ag, Hg, Rh, Ru, Pd, Os, Ir and Pt (see e.g. the German Encyclopedia, Römpp Chemie Lexikon, Thieme Verlag). Therefore, contrary to the Examiner's statement, the undoped Cu layer 13 of Nogami does not meet the "precious metal" limitation of claim 1.

Nogami does not show or teach the claimed invention.

The dopant material of Nogami is chosen to improve the electromigration resistance of the copper interconnects. Therefore, the problem underlying the present invention, i.e. the effective structuring of chemically inert precious metal layers, does not exist in Nogami and is not suggested by Nogami. Accordingly, a person skilled in the art who is faced with the problem to be solved by the present invention would not consider Nogami as a relevant reference. In addition, even if he or she would, a person skilled in the art could not discern any information, teaching, or suggestion from Nogami, because the methods for the structuring of a copper layer are not usually applied to the structuring of a precious metal layer.

Clearly, Nogami does not show "applying to the prestructured substrate **a precious metal and a donor material containing an additive which is not a precious metal** in two or more layers; subjecting the layers to **heat treatment** at a temperature of between approximately 400°C and approximately 800°C, **such that the additive diffuses into the precious metal** and an **alloy layer is produced**; and **polishing the alloy layer by chemical and mechanical means"**, as recited in claim 1 of the instant application. (emphasis added)

In the second paragraph under "Claim Rejections - 35 USC § 103" on page 5 of the above-identified Office Action, claims 1-3, 7, 11-13, and 15 have been rejected as being unpatentable over Kawakubo et al. (U.S. 5,952,687) (hereinafter "Kawakubo") in view of Azuma et al. (U.S. 5,708,302) (hereinafter "Azuma") under 35 U.S.C. § 103(a).

Kawakubo discloses in Figs. 4A - 4E a method of manufacturing a memory cell with a switching transistor and a storage capacitor. Fig. 4B represents a prestructured substrate 1 with the switching transistor 3, 4, 6a, 6b, a bit line 8, a contact plug 11, an insulating layer 9 and a polishing-stop layer 10. Next, a barrier metal film 12 made of titanium nitride is formed partly on the polishing stop layer 10 and partly on the inner surface of the trench (Fig. 4C). The bottom electrode 13 made of iridium is formed on the barrier metal film 12. Further, on the bottom electrode 13 a flattening insulating layer 16 made of boronsilicate glass (BSG) is formed. The barrier film 12 can be made of titanium, tantalum, tantalum nitride or the like. Thereafter, as shown in Fig. 4D, those portions of the barrier metal film 12, bottom electrode 13 and insulating layer 16, which were deposited on or above the polishing stop layer 10, are removed by mechanical polishing. Mechanical polishing is used since

the barrier metal film 12 and the bottom electrode 13 are very thin, 100 nm or less. (see column 7, lines 48-66).

However, as stated by the Examiner, Kawabuko do not disclose or teach the use of an additive contained in the donor material. Further, the reference does not disclose any heat treatment.

Azuma discloses a method for manufacturing a dielectric or ferroelectric integrated circuit capacitor with the emphasis on manufacturing a bottom electrode that adheres well and does not have short-inducing surface irregularities due to the diffusion or blooming of silicon. Fig. 1 shows a capacitor 20 including substrate 22, bottom electrode 24, metal oxide layer 26, and top electrode 28. Bottom electrode 24 includes a plurality of respective layers including adhesion metal portion 34, first noble metal portion 36, diffusion barrier region 38, and second noble metal layer 40. Adhesion metal portion 34 is preferably made of Ti or Ta, first noble metal portion 36 is preferably made of Pt, but may also be Au, Ag, Pd, Ir, Rh, Ru, Os or conductive oxides of these metals. After deposition, portions 34 and 36 are preferably annealed to promote their interdiffusion, thereby providing barrier region 38. Region 38 is defined as the material between lower dashed line 42 and upper dashed line 44. Interface 50 is positioned between adhesion metal portion 34 and first noble

metal portion 36, and represents the interlayer boundary at a time prior to the diffusion that forms barrier region 38 (see column 4, line 55 to column 5, line 20). The interdiffusion of portions 34 and 36 serves to increase the stability of the lattice, which correspondingly enhances resistance against diffusion through or from region 38 (see column 5, lines 38-41).

However, the titanium **layer 34 is not a precious metal layer** as acknowledged by the Examiner, since titanium is a transition metal from the IV group of the periodic table (see e.g., German Encyclopedia "Römpp Chemie Lexikon", Thieme Verlag). Further, Azuma does not disclose an additive with a "donor material containing an additive" as recited in claim 1. Therefore, Azuma does not disclose "a heat treatment... such that the additive diffuses into the precious metal", as set forth in claim 1. Still further, Azuma does not disclose the step of "polishing the alloy" as claimed.

Applicants submit that claim 1 is not obvious over Kawakubo in view of Azuma at least for the reasons stated below.

In the present invention according to claim 1, the donor material containing the additive is used to "weaken" the precious metal layer for a chemical mechanical polishing (CW) step in order to reduce the "risk of the formation of

scratches, which can render the chip unusable (see page 5, lines 15-16 of the instant specification).

On the other hand, Kawakubo also appears to use a CMP step for structuring the iridium layer 13. However, the method according to Kawakubo does not require a "weakening" of the iridium layer, since the iridium layer 13 is protected by the insulation layer 16 during CMP polishing (see Fig. 4D). Therefore, CMP polishing only scratches on the protecting layer 16, not on the surface of the iridium layer 13. CMP-induced scratches on the insulation layer 16, however, do not cause any harm since this layer is removed later anyway (see Fig. 4E). Therefore, a person skilled in the art who uses the method according to Kawakubo would not be motivated to look for a method that protects the precious layer from scratches. Moreover, a person skilled in the art who uses the method according to Kawakubo would not consider the method according to claim 1 as useful or relevant, since he or she would not want to increase, among other things, the number of processing steps without gaining much advantage from it.

Further, even if a person skilled in the art who is aware of Kawakubo would consider Azuma, he would find in Azuma a precious metal layer, e.g. iridium layer 36, a donor layer 34, e.g. titanium, but he would not find an additive. Further, even though Azuma discloses a heating step, a person skilled

in the art would only find that "the interdiffusion of portions 34 and 36 serves to increase the stability of the lattice" (see column 5, lines 38-39). This clearly is the opposite of what is needed in order to prepare a precious metal layer for a chemical mechanical polishing step according to the present claimed invention.

Therefore, it is apparent that Azuma does not overcome the deficiencies of Kawakubo and a person skilled in the art would not combine Kawakubo and Azuma to obtain an improvement for a chemical mechanical polishing of a precious metal layer as recited in claim 1.

Clearly, the references do not show "applying to the prestructured substrate a precious metal and **a donor material containing an additive which is not a precious metal** in two or more layers; **subjecting the layers to heat treatment** at a temperature of between approximately 400°C and approximately 800°C, **such that the additive diffuses into the precious metal** and an **alloy layer is produced**; and **polishing the alloy layer by chemical and mechanical means"**, as recited in claim 1 of the instant application. (emphasis added)

In the second full paragraph under "Claim Rejections - 35 USC § 103" on page 6 of the above-identified Office Action, claims 19-21 and 23 have been rejected as being unpatentable over

Kawakubo in view of Azuma and further in view of Russell et al. (U.S. 6,395,194) (hereinafter "Russell") under 35 U.S.C. § 103(a).

The foregoing discussion of Kawakubo and Azuma applies equally in the rejection of claims 19-21 and 23, which depend directly or indirectly on independent claim 1. Russell does not overcome the basic deficiencies of Kawakubo and Azuma Therefore, the claims are believed patentably distinguishable over the cited prior art for the reasons previously advanced.

In the second full paragraph under "Claim Rejections - 35 USC § 103" on page 7 of the above-identified Office Action, claims 19, 20, and 22 have been rejected as being unpatentable over Kawakubo in view of Azuma and further in view of Kirlin et al. (U.S. 5,976,928) (hereinafter "Kirlin") under 35 U.S.C. § 103(a).

The above discussions of Kawakubo and Azuma are applicable in the instant rejection of claims 19, 20, and 22, which depend directly or indirectly on independent claim 1.

Kirlin does not make up for the deficiencies of Kawakubo and Azuma. Therefore, claims 19, 20, and 22 are believed patentable over the prior art for the same reasons as previously advanced.

It is accordingly believed to be clear that none of the references, whether taken alone or in any combination, either show or suggest the features of claim 1. Claim 1 is, therefore, believed to be patentable over the art. The dependent claims are believed to be patentable as well, because they all are ultimately dependent on claim 1.

Finally, applicants appreciatively acknowledge the Examiner's statement that claims 4, 6, and 24 "would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims." In light of the above, applicants respectfully believe that rewriting of claims 4, 6, and 24 is unnecessary at this time.

In view of the foregoing, reconsideration and allowance of claims 1-35 are solicited.

In the event the Examiner should still find any of the claims to be unpatentable, counsel would appreciate receiving a telephone call so that, if possible, patentable language can be worked out.

If an extension of time for this paper is required, petition for extension is herewith made.

Please charge any fees that might be due with respect to Sections 1.16 and 1.17 to the Deposit Account of Lerner and Greenberg, P.A., No. 12-1099.

Respectfully submitted,

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